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WHEY BASED TOMATO SOUP POWDER: RHEOLOGICAL AND COLOR PROPERTIES

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ABSTRACT

Tomato soup provides several functional properties like satiating effect, nutrition and italso helpsin weight management. The aim of this study was to compare the rheological behaviour and color of experimental whey based tomato soup with tomato soup available in market. Experimental tomato soup fortified with whey powder, had more nutritive value and exhibited the rheological behaviour comparable to market samples. Experimental tomato soup exhibited shear thinning behaviour and followed Power law and Herschel Bulkley model. Viscosity of experimental tomato soup was similar as that of market soup and also showed pseudoplastic nature. LVR region for tomato soup samples was exhibited between 0.04 to 0.7 % strains. Apparent viscosity of experimental soup sample with 18% total solids (ES18) exhibited time-independent property. Lycopene was not degraded during processing and retained the natural red colour and was in agreement with *L*, *a*, and*b*readings.

KEYWORDS: Tomato Soup, Whey Powder, Steady State Rheology, Dynamic Viscoelastic Properties, Time Dependent Rheological Properties, Color, Lycopene

INTRODUCTION

Traditionally, soups are classified into two broad groups: clear soups and thick soups. Thick soups are further classified into purees which are vegetable soups thickened with starch, bisques made from pureed shellfish thickened with cream, cream soups in which bechamel sauce is used as a thickening agent and veloutes which are thickened with eggs, butter and cream. Apart from the above mentioned thickening agents generally for thickening rice, flour, and grain also are employed. In the global market soups are available in different forms including dried soup powder, canned soup, chilled soup, frozen soup and in recent years for consumer's convenience soup is also Ultra-high temperature (UHT) treated followed by aseptic packaging.

Dry soup mixes, are more often accepted by the consumers as they can be stored for long duration even at room temperature and also requires a less storage space. Dry soup mixes are prepared either blending dried ingredients along with thickening agents or by spray drying the formulated slurry of soup (Riddolls, 1972; Singh et al., 2003). Rice bran, rice

and corn flours have also been reported to act as thickening agent in manufacturing of soup (Arro, & Leon, 1982; Jayadeep et al., 2008; Sabanis, & Tzia, 2008). Yadav et al. (2006, 2007a, b) have reported the functional properties of potato flour which was modified by physical, chemical, and enzymatic treatments. Rekha, Chauhan, Yadav, Guha, & Ramteke, (2005) reported that modified potato flour can be utilized in soup mix formulation and which in turn increased the pasting viscosities, and also the property to hold more amount of solids. Whey proteins are used as a functional ingredient in a food system like soup and are often responsible for affecting the structure, appearance, texture, viscosity, mouth feel, or flavor retention property (Morr, & Ha, 1993). Functionality of whey proteins to form gel network is generally affected by factors like: temperature, pH, protein concentration, salt, sugars, calcium, and free sulfhydryl groups in the system (Jayaprakasha, 1992; Rich, & Foegeding, 2000; Foegeding et al., 2002).

Tomato soup is a normally consumed for its smooth texture and provides instant satiety effect. Tomato soups available in the market are generally manufactured by dry blending of ingredients in which tomato powder and thickening agent forms the major part of the formulation. Rheological behaviour and color properties of tomato soup are the important parameters which decide its acceptability by the consumers. Flow behaviour of tomato soup is usually affected by constituents and the temperature of the soup while, color is generally affected by the extent of lycopene degradation during processing and binding arrangements with other molecules of soup (Ahmed, Rico, Martin-Diana, & Barry-Ryan, 2011a, b, 2012).

The objective of the study was to evaluate the rheological properties of experimental soups with different total soluble solids (TSS) for steady state rheology at selected temperatures followed by rheological model fitting. Selected experimental soup sample was further compared with market samples for their rheological, color properties and lycopene content.

MATERIALS AND METHODS

Materials

Experimental tomato soup was formulated by using tomato powder (34g), whey powder (42 g), salt (9.87 g), sugar (11.13 g), yeast extract (3 g), citric acid (0.08 g), creamer (3 g), tomato flavour (1.02 g) and pectin (1.84 g). Four market samples of reconstitutable tomato soup powder (MS1, MS2, MS3, MS4) were collected from local market of Delhi, India (Table 1). Tomato soup powder was first diluted with deionised water as per listed in Table 1 and heated through hot plate up to 80^{o}C for 10 min before subjecting them for rheological parameters.

METHODS

Rheological Behaviour of Tomato Soup

Steady state rheological behaviour of tomato soup was determined at five different temperatures i.e. 25, 30, 35, 40 and 45^{o}C, using MCR 52 Rheometer (Anton Paar, GmbH, Germany) with a50 mm diameter parallel plate geometry (PP50)with a 1 mm gap as earlier discussed by Choi, Mitchell, Gaddipati, Hill, & Wolf (2014). Rheological behavior of all the tomato soup samples were analyzed in triplicate and its average were used for estimating the Power-law and Herschel-Bulkley model parameters.

Steady State Rheology

The tomato soup samples were analysed using rheometer as a function of shear rate at 25, 30, 35, 40 and 45°C. The relationship between shear rate vs shear stress (τ) and shear rate vs apparent viscosity (η) was analysed under steady state rheology and the range of shear rate applied on sample was from 0.1 to $100s^{-1}$. Viscosity of tomato soup samples (MS1, MS2, MS3, MS4 and ES18) were compared at 100 shear rate (s^{-1}) as a function of temperature. Power-law and Herschel-Bulkley models were used to verify the data of steady state rheology of tomato soupsas earlier discussed by (Heikal, &Hinnan, 1990).Power-law and Herschel-Bulkley model provides a mathematical rheological relationship between shear rate and shear stress which is used to verify the flow behaviour of tomato soup and is given as follows:

Power-law, $\tau = K(\gamma)^n$

Herschel-Bulkley model, $\tau = \tau_0 + K(\gamma)^n$

Where, K = flow consistency constant ($Pa \cdot s^n$), n = flow behaviour index (dimensionless) τ = shear stress (Pa), τ_0 = yield stress (Pa) and γ = shear rate (s^{-1}).

Time Dependent Rheological Properties

Time dependent rheology was studied as mentioned in 2.2.1. Before running the sampleit was allowed to stabilize between the plates for 10 min for temperature equilibrium and then subjected to constant shear rate ($10s^{-1}$). Time dependent rheological properties (shear stress and apparent viscosity) of the experimental (ES18, ES14 and ES10) and market samples were measured in triplicate at selected temperature 45°C. Samples were sheared at a particular shear rate and temperature for 300 s and the corresponding shear stress and apparent viscosity values were considered as the equilibrium shear stress and viscosity values at a given shear rate and temperature (Basu et al., 2013).

Dynamic Viscoelastic Properties

The dynamic viscoelastic properties were measured using a Modular Compact Rheometer as mentioned 2.2.1.2. The measurements were carried out at 10°C and the readings were taken in triplicate by using amplitude sweep program. The linear viscoelastic region was determined by taking constant strain at 5% and frequency sweeps from 10 to 0.01 Hz. The storage modulus (G′), loss modulus (G″) and loss tangent (tan δ or tan G″/G′) were recorded with the software (Data analysis, Anton Paar Gmbh, Austria, Europe) (Chantaro et al., 2013).

Color Parameters

Color properties of tomato soup samples (MS1, MS2, MS3, MS4 and ES18) was measured by using Handheld Chroma meter (CR-400, Konica Minolta, UK) at 45^0C and were recorded in the CIE L, a, b scale. (Hutchings, 1994) "L" represents the lightness index ("0" for black to "100" for white), "a" represents greenness and redness ("+100" for red and "-80" for green) while, "b" represents for yellowness and blueness ("+70" for yellow and "-80" for blue). All of the tomato samples were analyzed in triplicate and average values were reported.

Lycopene Content

The lycopene content of all the tomato soup samples was evaluated under UV-Visible spectrophotometer (SL 159, ELICO, India) at 503 nm by the method described by Davis, Fish, & Perkins-Veazie (2003). Tomato soup powder was

dispersed in deionised water and with the help of micropipette, 100 ml of the sample was transferred into test tube to which 8.0 ml of hexane: ethanol: acetone (2:1:1) mixture was added, followed by mixing using a vortex mixer. One ml of water was added to each prepared sample which was vortexed again and left undisturbed for 10 min at room temperature. Cuvette of spectrophotometer was rinsed with blank sample before analyzing the experimental samples at 503 nm and the lycopene content was expressed as mg/kg of the tomato soup and calculated as,

Lycopene (mg/kg) = (A503 x 537 x 8 x 0.55) / (0.10 x 172) = A503 x 137.4

Where, molecular weight of lycopene is 537g/mole, volume of mixed solvent is 8 ml, volume ratio of the upper layer to the mixed solvent is 0.55, weight of tomato soup sample added is 0.10g and extinction coefficient for lycopene in hexane as 172 mM^{-1}. All of the samples were analyzed in triplicate and the average values were considered for reporting lycopene content.

Statistical Analysis

All the experimentswere performed in triplicate and results were shown as mean ± standard error. Analysis of variance (ANOVA) was used with the help of statistical software (Origin Pro 9.1, Austin, Texas, United States). The verification of model fitting was verified with the help of coefficient of determination (R^2). In thepresent study the significance level was used at $P<0.05$.

RESULTS AND DISCUSSIONS

Rheological Measurements

Steady State Rheology

Freshly prepared experimental samples (ES) of tomato soup were assessed for its shear thinning properties using a parallel plate at five different temperatures (25, 30, 35, 40 and $45^{O}C$) with different TSS (18, 16, 14, 12 and 10^{o}brix) and similar behaviour was suggested by Ravindran, & Matia-Merino (2009) for starch-fenugreek soup. The shear stress behaviour of ES with different TSS increased with increase in shear rate from 0.1 to 100 s^{-1} in convex mode as reported by Barbana, & El-Omri (2012) in case of tomato concentrate. At all temperatures (25 to $45^{O}C$), shear stress of ES18 was higher as compared to other experimental sample (Fig. 1) while apparent viscosity decreased with increase in temperature (Fig. 2). Equivalent result was reported by Barreiro, Sandoval, Guedez, & Luciani, (1996) in tomato concentrate. Experimental sample containing 18% TSS (ES18) showed higher apparent viscosity as compared to other samples and the property may be attributed to the higher soluble solids. Shear stress also increased with increasing total soluble solid of experimental tomato soup and was highest in ES18 at all temperatures i.e. 25, 30, 35, 40 and $45^{O}C$ and was therefore used for comparative analysis with different market samples of tomato soups.

The pseudoplastic behaviour of MS1, MS2, MS3, MS4 and ES18 at five different temperatures (25, 30, 35, 40 and $45^{O}C$) was determined from the graph between the shear rate 0.1 to 100 (s^{-1}) and shear stress (Pa) (Fig. 3) as suggested by (Ibanoglu, & Ibanoglu, 1999). The viscosity of soup decreased with an increase in shear rates and was significantly ($P<0.05$) different from each other and which justified their shear-thinning property. Rheological behaviour of ES18 was comparable with market samples (MS1, MS2, MS3 and MS4) of tomato soup. MS1 showed maximum viscosity as compared to MS2, MS3, MS4 and ES18 at each and every shear rate at all temperatures (25, 30, 35, 40 and $45^{O}C$). It may be due to the addition of thickening agent and fat content in MS1 sample.

Viscosity of MS1 was significantly lower as compared with other samples, while ES18 showed the lowest viscosity signifying the fastest structural recovery. Structural recovery was observed in milk gels studied by Girard, &Schaffer-Lequart (2007) which were attributed to the weakly charged and low-molecular weight that allowed best recovery of the texture rendered to shearing. The structural recovery ofES18 signified that after preparing the tomato soup the mouthfeel would be better for longer time as compared to other samples. Viscosity of all the soup samples (MS1, MS2, MS3, MS4 and ES18) was found to decrease with respect to increase in temperature from 25, 30, 35, 40 and 45^{O}C when subjected to a constant shear rate 100s^{-1} (Figure. 4).

The rheological behaviour of tomato soup samples subjected to an increasing shear rate at different temperatures (25, 30, 35, 40 and 45^{O}C) was modelled using the Power Law and Herschel-Bulkley models (Table. 2 and 3). Yield stress values for majority of tomato soup samples were next to zero.

Flow behaviour index (n) was observed to be less than one for Power-law and Herschel-Bulkley model which justified shear-thining behviour of all the tomato soup samples (MS1, MS2, MS3, MS4 and ES18). R^2 value of about 0.999 was obtained and the models fitted perfectly suggesting that their existed a significant difference in all of the tomato soup samples and was in total agreement with the results reported for tomato concentrate by Harper, & El Sahrigi (1965). Consistency coefficientof ES18 obtained through Power-law decreased continuously with increasing the temperature from 25 to 45^{O}C (Fig. 5) and is in compatible with the observation of Basu, Shivhare, & Singh (2013) in mango jam. However in Herschel-Bulkley model, variation of consistency coefficient (K) of ES18 with temperature was not systematic.

Dynamic Viscoelastic Properties

The viscoelastic behaviour of tomato soup samples (MS1, MS2, MS3, MS4 and ES18) were evaluated using a strain sweep measurement and results are acquainted in (Fig. 6). All samples showed increased value of G' when compared to G", which indicated that the samples were more elastic than viscous with Linear Viscous Region (LVR). Similar observations for viscoelastic behaviour were reported by Tiziani and Vodovotz, (2005) in case of tomato juice. LVR region for tomato soup samples was exhibited between 0.04 to 0.7% strains (Table 4). The reason for LVR region of soup samples may be due to the interaction of fat and water molecule as described earlier by Rayner, Marku, Eriksson, Sjoo, Dejmek, & Wahlgren (2014) for topical cream.

Elastic property was significantly higher in MS2 sample as compared to other samples and the reason may be attributed to the coarse-grained structure, while other samples were fine powder. A coarse-grained particle of MS2 usually forms a complex interaction with water molecules, which in turn forms a strong gel network and provides elasticity to tomato soup and was in agreement with the observation for mixture of waxy corn and waxy rice starch by Lu, Duh, Lin, & Chang (2008). ES18 also showed same dynamic behaviour when compared with market tomato soup samples. From Fig. 7, it was observed that initially MS2 was more viscous which gradually decreased with increasing strain (%) as compared to other tomato soup samples. At a strain of 100 %, MS1 exhibited maximum viscous property which is due to higher amount of fat which helps to form a fine emulsion with water molecule of soup. The viscous nature was confirmed by the results of steady state rheology, where MS1 had the maximum viscosity even at 100 shear rate (s^{-1}).

Time Dependent Rheological Properties

Time dependent rheogram confirmed non-newtonian behaviour of tomato soups (ES18, ES14 and ES10) at 45°C with a time-dependent constant shear rate of 10 s^{-1} and showed fewer changes in their structure after shearing the samples

for 300 s. ES18 sample showed maximum viscosity when compared to ES10 and ES14 and the reason may be attributed to high soluble solid comprising of whey powder and tomato powder. Apparent viscosity of ES18 continuously exhibited time-independent property and its values occurred in the range of apparent viscosity of MS3 and MS4, while MS1 and MS2 recorded more viscosity as compared to ES18. Apparent viscosity of MS1 initially decreased with time within the first 20 s of shearing time and obtained a constant value corresponding to an equilibrium state after 20s (Fig.8). The reason for the behaviour of MS1 may be attributed towards the higher fat content as compared which forms fine emulsion with water present in soup. Similar result was described earlier by Chung and McClements (2014) for sauces.

Color Properties

Color of market sample as compared to ES18 were statistically different ($P<0.05$) (Table 5). Value of 'a' was found to be positive in all soup samples and was maximum in MS1 followed by ES18 signifying the presence of red color (Fig. 9). Enhanced redness of the ES18 may be due to the presence of whey protein that completely binds lycopene from tomato powder during processing and also retains it during the storage as reported by Ahmed, Rico, Martin-Diana,&Barry-Ryan (2012) in cheese whey permeates fortified with fresh cut tomato. Value of 'L' and 'b' were slightly higher in market samples (MS1, MS2, MS3 and MS4) as compared to ES18 that may be due to the presence of corn flour and other thickening agents which increases the lightness and yellowness. Addition of whey powder with tomato powder helped to maintain the red color of tomato soup thereby eliminating the necessity of adding artificial color.

Lycopene Content

Lycopene levels in the hexane extracts were calculated as (Lycopene, mg/kg = A503 x 137.4) (Table 6) and was correlated with absorbance and obtained straight line. The value of correlation coefficient (R^2) was 0.97 for tomato soup samples. The data of straight line squares fitted to the tomato soup samples verified the equation as, $y = 6.9565x - 0.0072$ (Fig. 10). This equation was used for estimating lycopene content in by measuring the scattered absorbance at 503 nm of the tomato soup and the values ranged from 0.09 to 0.15 mg/kg. Similar lycopene content was reported by Davis, Fish, &Perkins-Veazie,(2003) in tomato products like tomato ketchup, tomato paste and tomato sauce etc. ES18 contained significantly higher lycopene (0.15 mg/kg) as compared to other sample and was due to usage of higher amount of tomato powder during manufacturing of tomato soup powder.

CONCLUSIONS

The rheological method has been accomplished to characterize and determined flow behavior of different tomato soup samples at 25, 30, 35, 40 and 45^{O}C. Shear thinning behavior of different tomato soup samples at all temperatures was confirmed by steady state rheology and the data was verified by Power-law and Herschel-Bulkley model. Consistency coefficient (K) decreased with increase in temperature and was well fitted in power-law model; however variation of K with temperature was not systematic in Herschel Bulkley model. All soup samples showed an increased value of G' as compared to G" indicating elasticity. Apparent viscosity of ES18 exhibited time-independent property was more viscous as compared to other sample. Presence of whey proteins which has a tendency to bind lycopene resulted in retention of redness in ES18.

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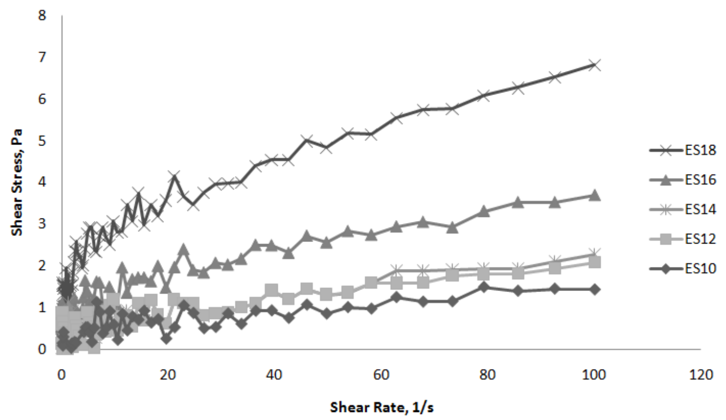

Figure 1: Steady State Rheology of Tomato Soup Samples at 45°c

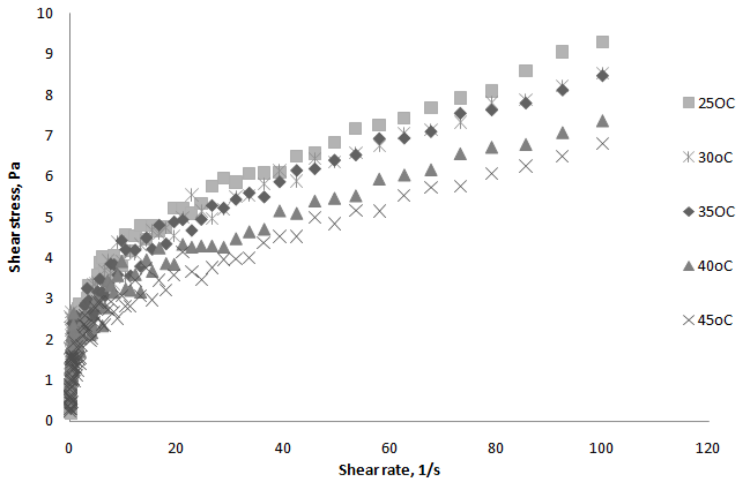

Figure 2: Steady State Rheology of ES18 At 25-45°c

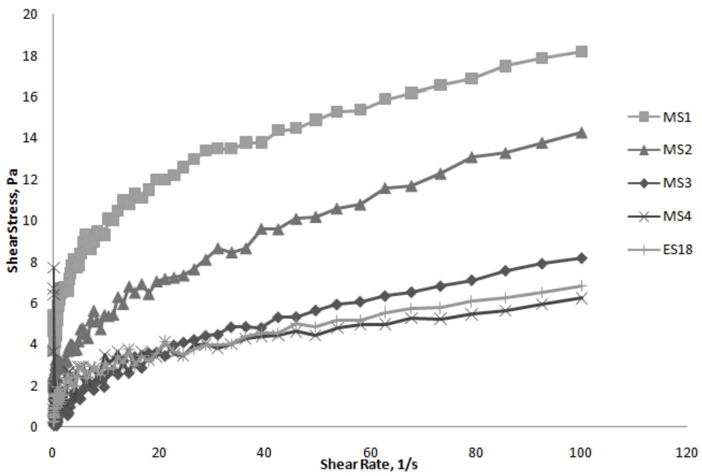

Figure 31: Rheogram of Tomato Soup Samples at 45°c

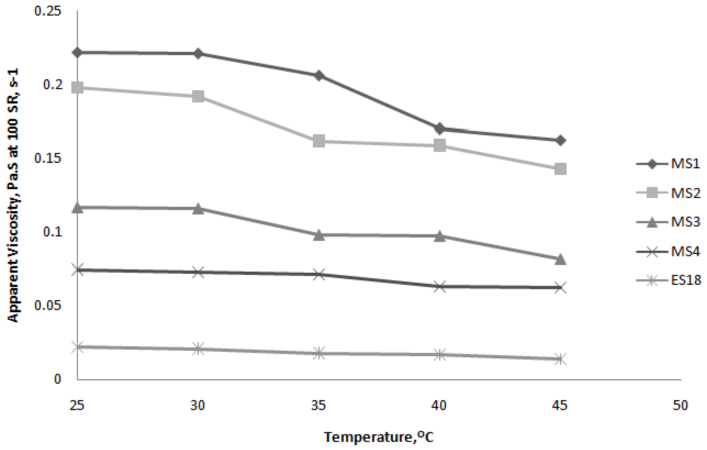

Figure 4: Apparent Viscosity of Tomato Soup Samples as a Function of Temperature at Constant Shear Rate 100s^{-1}

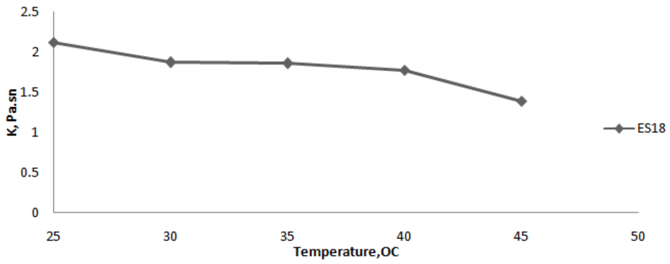

Figure 5: Rheogram of Consistency Coefficient, K (Pa•S^n) Of ES18 as a Function of Temperature

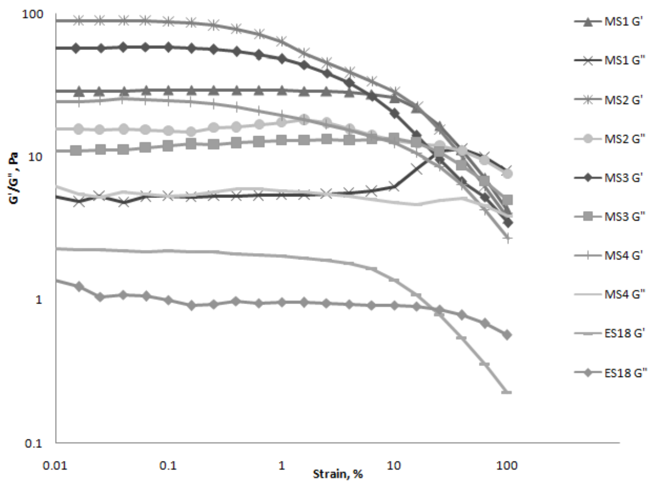

Figure 62: Elastic Modules and Viscous Modules as a Function of Strain (%) for Tomato Soup

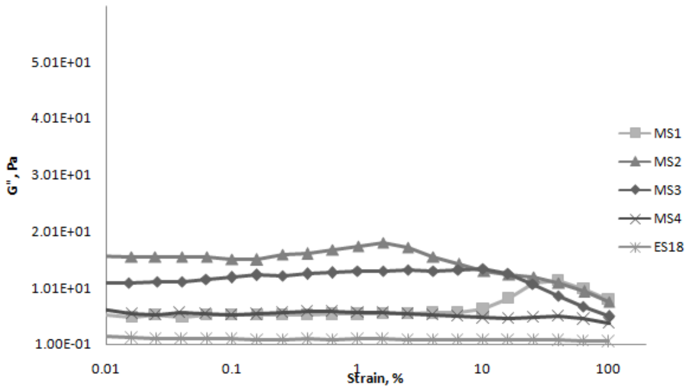

Figure 7: Viscous Modules as a Function of Strain (%) for Tomato Soup

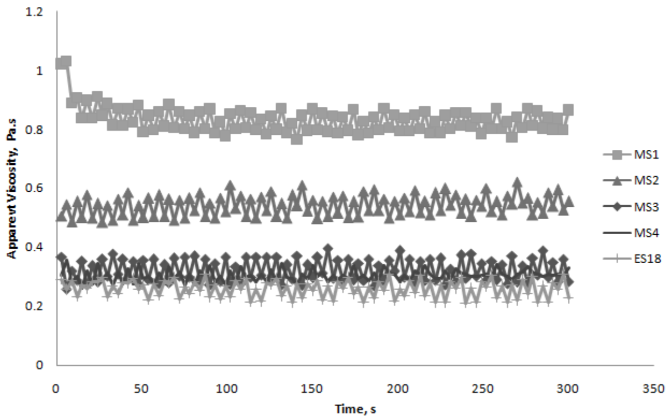

Figure 8: Time Dependent Rheogram of ES18 Vs Market Tomato Soup Samples as a Function of Time

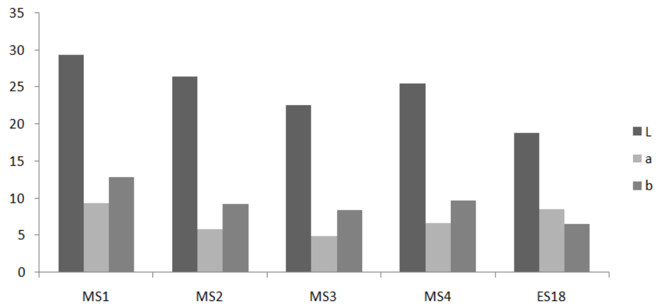

Figure 93: Color Parameters of Tomato Soup Samples at 45^{o}c

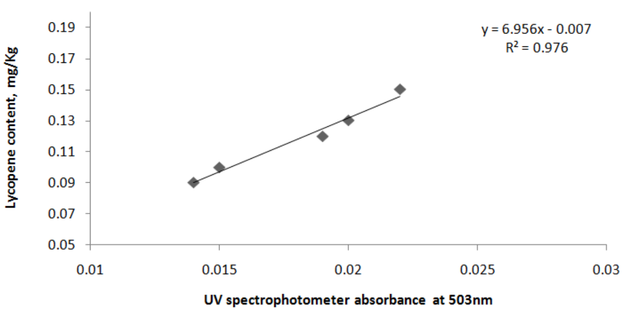

Figure 40: Linear Absorbance Graph of Different Tomato Soup Samples at 503nm

Table 1: Reconstitution and Coding of Tomato Soup Samples for Rheological and Color Properties

Tomato Soup Sample	Code	Soup Powder (G)/Deionised Water (Ml)
Market sample 1	MS1	55/600
Market sample 2	MS2	54/600
Market sample 3	MS3	60/600
Market sample 4	MS4	60/600
Experimental Sample (TSS 18)	ES18	80/600
Experimental Sample (TSS 16)	ES16	75/600
Experimental Sample (TSS 14)	ES14	70/600
Experimental Sample (TSS 12)	ES12	65/600
Experimental Sample (TSS 10)	ES10	60/600

Table 2: Data of Herschel-Bulkley Parameters of Tomato Soup Samples at Different Temperatures

Temp. (^{O}c)	Parameters	Ms1	Ms2	Ms3	Ms4	Es18	*P-Value
25	Y.S (Pa)	0.354±0.03	4.024±0.02	1.457±0.04	-0.565±0.06	1.21±0.06	< 0.05
	K (Pa.s^n)	0.881±0.02	2.417±0.03	1.904±0.02	1.599±0.06	0.971±0.01	< 0.05
	n	0.54±0.06	0.436±0.02	0.475±0.01	0.327±0.02	0.434±0.01	< 0.05
	R^2	0.989	0.995	0.992	0.976	0.967	
30	Y.S (Pa)	-0.089±0.01	7.517±0.03	1.89±0.15	0.054±0.01	-0.336±0.04	< 0.05
	K (Pa.s^n)	1.148±0.02	0.854±0.01	1.701±0.07	1.767±0.15	2.176±0.01	< 0.05
	n	0.509±0.01	0.633±0.05	0.479±0.03	0.285±0.01	0.293±0.08	< 0.05
	R^2	0.991	0.961	0.992	0.963	0.972	
35	Y.S (Pa)	-0.264±0.04	4.541±0.04	1.124±0.08	2.158±0.04	-1.317±0.01	< 0.05
	K (Pa.s^n)	0.911±0.01	1.984±0.01	1.423±0.11	0.747±0.04	3.12±0.02	< 0.05
	n	0.516±0.01	0.463±0.03	0.489±0.01	0.437±0.01	0.251±0.02	< 0.05
	R^2	0.989	0.989	0.993	0.913	0.982	
40	Y.S (Pa)	-0.242±0.01	4.232±0.04	0.621±0.01	0.835±0.01	0.671±0.04	< 0.05
	K (Pa.s^n)	0.928±0.02	1.372±0.01	2.152±0.02	0.661±0.03	1.071±0.04	< 0.05
	n	0.516±0.01	0.463±0.05	0.426±0.03	0.424±0.01	0.381±0.01	< 0.05
	R^2	0.991	0.983	0.992	0.939	0.966	
45	Y.S (Pa)	-0.232±0.02	2.013±0.01	1.605±0.01	1.851±0.01	0.167±0.04	< 0.05
	K (Pa.s^n)	0.816±0.01	3.746±0.04	1.164±0.03	0.195±0.01	0.168±0.02	< 0.05
	n	0.509±0.01	0.315±0.01	0.516±0.01	0.69±0.09	0.027±0.01	< 0.05
	R^2	0.989	0.989	0.987	0.519	0.964	

*Mean value of triplicate (n=3) shows significant differences ($P<0.05$) using ANOVA.
Y.S = Yield stress (Pa)
K = Flow Consistency Constant (Pa•s^n)
n = Flow behaviour index (Unitless)
R^2 = Ccoefficient of determination

Table 3: Data of Power-Law Parameters of Tomato Soup Samples at Different Temperatures

Temp. (^{O}c)	Parameters	MS1	MS2	MS3	MS4	ES18	*P-Value
25	K (Pa.s^n)	6.328±0.07	1.145±0.04	3.186±0.16	1.079±0.06	2.100±0.09	< 0.05
	n	0.226±0.09	0.456±0.08	0.353±0.08	0.407±0.05	0.264±0.05	< 0.05
	R^2	0.974	0.988	0.986	0.973	0.953	
30	K (Pa.s^n)	8.364±0.06	1.093±0.09	3.47±0.20	1.858±0.04	1.854±0.15	< 0.05
	n	0.188±0.06	0.519±0.02	0.349±0.05	0.273±0.08	0.332±0.04	< 0.05
	R^2	0.851	0.991	0.979	0.966	0.971	
35	K (Pa.s^n)	6.502±0.09	0.741±0.05	2.453±0.05	2.718±0.39	1.849±0.05	< 0.05
	n	0.241±0.05	0.556±0.04	0.363±0.05	0.185±0.02	0.346±0.05	< 0.05
	R^2	0.957	0.988	0.987	0.877	0.977	

Table 3 – Cond.,

40	K (Pa.s^n)	5.533±0.09	0.755±0.05	2.554±0.46	1.483±0.12	1.64±0.33	< 0.05
	n	0.231±0.03	0.544±0.03	0.355±0.05	0.273±0.02	0.285±0.01	< 0.05
	R^2	0.939	0.991	0.99	0.927	0.961	
45	K (Pa.s^n)	5.734±0.08	0.676±0.02	2.637±0.05	1.946±0.04	1.457±0.47	< 0.05
	n	0.242±0.03	0.557±0.04	0.363±0.02	0.241±0.05	0.349±0.03	< 0.05
	R^2	0.986	0.988	0.972	0.426	0.963	

*Mean value of triplicate (n=3) shows significant differences (P<0.05) using ANOVA.

K = Flow Consistency Constant (Pa•s^n)

n = Flow behaviour index (Unitless)

R^2 = Coefficient of determination

Table 4: Lvr Region of Different Tomato Soup Samples

Sample	LVR Region (%), At 25^{0}C
MS1	0.0396
MS2	0.0623
MS3	0.7010
MS4	0.7020
ES18	0.0622

Table 5: Data of Colour Parameters of Tomato Soup Samples at 45^{o}c

Sample	L	A	B	*P-Value
MS1	29.256 ± 0.221	9.32 ± 0.338	12.863 ± 0.211	< 0.05
MS2	26.32 ± 0.350	5.84 ± 0.173	9.263 ± 0.268	< 0.05
MS3	22.543 ± 0.379	4.883 ± 0.097	8.433 ± 0.480	< 0.05
MS4	25.463 ± 0.488	6.63 ± 0.451	9.69 ± 0.494	< 0.05
ES18	18.813 ± 0.181	8.54 ± 0.387	6.52 ± 0.444	< 0.05

*Mean value of triplicate (n=3) shows significant differences (P<0.05) using ANOVA.

Table 6: Lycopene Content of Tomato Soup Samples

Sample	OD Value at 503nm	Lycopene Content (Mg/Kg)
MS1	0.02	0.13
MS2	0.015	0.1
MS3	0.014	0.09
MS4	0.019	0.12
ES18	0.022	0.15